How we eliminated nuisance alarms and increased time between shutdowns on our hydrogen recycle unit

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The hydrogen recycle unit (Figure 1) at our facility is a critical piece of equipment in the platformer process, which produces high octane gas, a product which is in high demand. In addition, the hydrogen recycle unit produces hydrogen as a byproduct. The hydrogen is used elsewhere in the process and in three other hydrogen-consuming processes within the refinery: Unicracker, PENEX, and MTBE production.

Many hydrogen recycle units in operation today have little or no diagnostics that can alert plant personnel to possible problems in the process or the health of the compressor train itself. In these units, vibration, bearing temperature, and oil temperature systems are independent, and each could shut down the entire process. In the past, MAP had no way to differentiate between false trips caused by instrumentation failures and legitimate machine trips. The result was that our unit frequently went into alarm and shut down unnecessarily, and revenues were lost. At one point, 87% of all major rotating equipment alarms at MAP were caused by instrument failures. This was a huge, unjustified expense which we knew we had to address.

Figure 1. Hydrogen Recycle Unit.

Reason for installing a new system

Since the hydrogen recycle unit is a critical machine at our facility, it was important to keep this unit running for long periods of time. We also needed to be sure the equipment operated efficiently and safely and had a long life expectancy.

There were three main reasons why we upgraded the controls on the turbine and compressor train:

- Eliminate costly nuisance alarms due to instrument failures.
- Lengthen unit runtime between shutdowns to a ten-year minimum.
- Meet stringent ISA-584.01 requirements.

We chose Bently Nevada Corporation and Woodward Governor Company to supply a complete integrated system, as we have successfully worked with both companies for many years.

Control System benefits

The system was flexible enough to implement numerous improvements:

- A control and monitoring plan that eliminates false or nuisance alarms due to instrument failures and provides shutdown verification using a comprehensive diagnostics program and troubleshooting system.
- Engineering workstations for online monitoring, control, trending, and machinery diagnostics.
- Fault-tolerant control for the turbine and compressor, including surge control.
- Remote control of the turbine and compressor train, while automatic protection, monitoring, and operation of the turbine and compressor train continue.
- A new seal-oil system, using dry gas seals, including dry gas seal system monitoring and bearing temperature monitoring for overall condition monitoring and predictive maintenance.
- Automatic turbine and compressor startup with remote control of turbine and compressor strings while automatic protection, monitoring, and operation of the turbine/compressor string continues.
- An integrated Bently Nevada 3500 and Data Manager® 2000 for Windows NT Machinery Protection/Management System to provide early identification of machinery problems, such as unbalance, misalignment, shaft crack, or bearing failures.
- Digital overspeed protection (which replaces the standard mechanical overspeed bolt) for the steam turbine.

Control System

The control system consists of several parts: a Bently Nevada 3500 Machinery Protection System integrated into a Woodward NetCon® fault-tolerant digital control system, two I/O banks, an overspeed protection system, a CTC touch-screen operator interface at the turbine deck, a Citect engineering workstation for control from the control room, and a Bently Nevada Data Manager 2000 Workstation (Figure 2).

Integrating the vibration analysis equipment

The 3500 Machinery Protection System includes a Transient Data Interface External (TDIX) System for storage of data taken during steady state and transient (startup and shutdown) conditions. A Bently Nevada Data Manager 2000 System displays the data for vibration analysis while the turbine is running *and* after a trip. The TDIX Communications Processor is constantly sampling waveform data and keeps the most recent data in a special memory buffer. When an alarm activates, the system captures machinery data for immediate retrieval and use. This plays a critical role in our machinery management system because our process personnel have immediate access to current and historical condition information in order to make quick, informed operating decisions.

Factory Acceptance Testing

Another benefit associated with this solution is the joint support for Factory Acceptance Testing (FAT) of the integrated systems. Bently Nevada System Integration Engineering and Product Service resources can work together with Woodward project and testing personnel to do a complete "one-stop" FAT. This helps to address and solve any possible integration issues early in the test phase, as opposed to trouble shooting in the field. *(See sidebar for more information on integration of Bently Nevada & control systems.)* Bently Nevada and Woodward also provided on-site field support during the actual installation, final integration, and system commissioning at our plant.

Life extension

Since the hydrogen recycle unit is a critical machine, we want to be able to run it for at least ten years before a scheduled shutdown. Addition of the performance monitoring module will help us to evaluate and extend the machine's life. The system takes measurements across the entire operation of the turbine and compressor train and then calculates efficiencies in actual percentages. We can measure the integrity and deterioration of the unit, perform online cleaning of the turbine and compressor, and schedule maintenance. MAP is very pleased with the performance monitoring and shutdown verification logic provided by this system. With this system in place, we now feel we can postpone a shutdown for fifteen to seventeen years. This clearly justifies the upgrade.

Eliminating false trips due to instrument failures

An in-depth alarm system virtually eliminates false trips caused by instrument failures. The shutdown system has four levels of alarm indications before a shutdown can occur:

- Signal failure
- Hi alarm
- Hi-Hi alarm
- Shutdown with verification

The system indicates on the screen when an alarm setpoint has been reached. If an alarm is displayed, the Operator can display a trend of related parameters. The Operator can then use each of the related parameters to decide if the alarm is real.

If the related parameters are stable

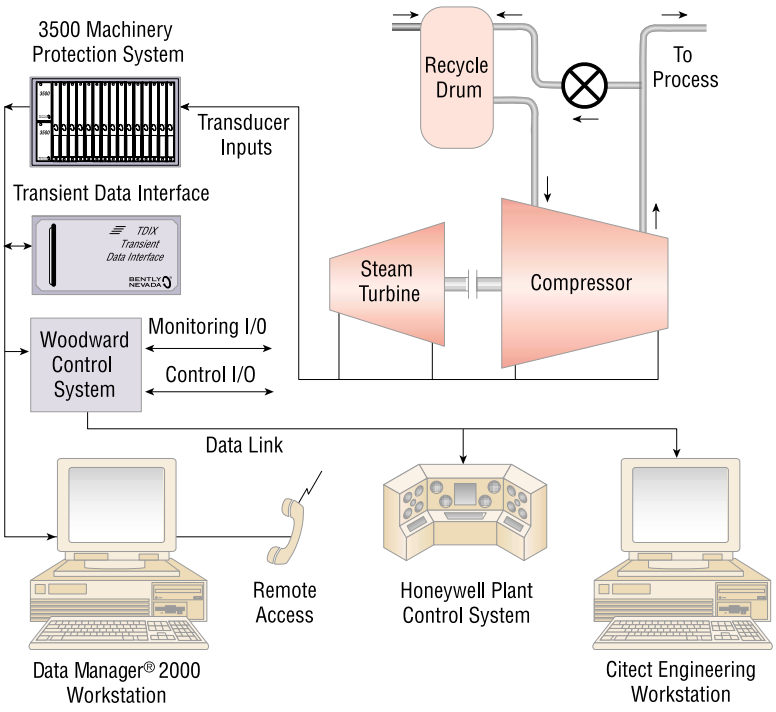

Figure 2. Integrated machinery monitoring, management, and control system.

and within acceptable operating limits, the failing device and alarm can be ignored. Since the electronic circuits are redundant or triple redundant, the failed device can be replaced without interrupting the machine's operation.

Before a shutdown can occur, the system uses specific shutdown logic for each situation. When an alarm is displayed, certain parameters must also indicate problems before the alarm can shut down the machine. This eliminates shutdowns due to instrument failures.

Real time trending

If a shutdown does occur, real time trending and an archive of information are available. Knowing what caused the shutdown helps to determine whether to begin an immediate hot start or to leave the machine shut down until maintenance can be performed. Information from the Woodward NetCon and Bently Nevada 3500 and Data Manager 2000 Systems is used to make these decisions. The Data Manager 2000 provides detailed steady state and transient data plots to help determine the condition of the machine.

Diagnostic and monitoring screens

MAP's diagnostic system uses 36 shutdowns and nearly 400 alarms to make it as easy as possible to troubleshoot and find problems. The operating and monitoring screen graphics are found on both the Citect-based OpTrend and the CTC local turbine deck station. These screens include:

- System overview
- Compressor detail
- Dry gas seal detail
- Turbine detail
- Lube system detail

Integrating data from Bently Nevada's 3500 Series Machinery Protection System into your DCS, PLC, or HMI

Getting critical operator information from your Machinery Protection System to your Distributed Control System (DCS), Programmable Logic Controller (PLC™), or Human Machine Interface (HMI) has never been easier thanks to Bently Nevada's 3500 Machinery Protection System. That's because we've focused on communications capabilities that are flexible and highly robust – exactly what you need when entrusting critical statuses and data from your machinery protection system to a digital link for communication with your other plant control and automation systems. We know that Operators rely on data from the machinery protection system to tell them when something out of the ordinary is occurring with their machines...much as you rely on your car's dashboard to convey "at-a-glance" statuses and operating conditions. We also know this link needs to provide numerous data types with extremely high reliability (imagine having to drive without a dashboard…even for a few miles). Finally, we know that it must be flexible and easy to implement, reducing your costs of integration. We've been listening. The result: our new 3500/92 Communication Gateway module.

Flexible integration

A typical monitor channel may provide data, such as current proportional values, a date/time stamp, channel alarm status, or module status information. The 3500/92 Communication Gateway has configurable Modbus® registers that allow users to identify the data that is most important for their applications and place that data in contiguous registers. The result is a system that is more easily adaptable to the addressing schemes of the host, uses the host's memory more efficiently, and allows the host to access data from the 3500 System more quickly. This means fewer hardware communications devices and less programming are required – your overall costs to integrate the 3500 System are reduced.

What protocol will I use?

This really depends on what DCS, PLC, or HMI you are using. The 3500/92 was designed to be flexible, so it could communicate with all of these systems. The 3500/92 uses the Modbus protocol, which is compatible with virtually every process control or automation system currently in use. Specifically, it supports Modbus over RS232, RS422, and RS485, all reliable and common serial communications

links. In addition, the 3500/92 provides an Ethernet TCP/IP interface for third party systems that have Modicon's new Modbus/TCP protocol (also known as Modbus over Ethernet.) A relatively new development, Modbus/TCP is the industry-standard Modbus protocol designed to communicate over Ethernet TCP/IP rather than the traditional serial data link.

Get the most from your system – call SIE

Easy connectivity is only half the picture. To get the most out of your Bently Nevada system, you need people who can show you what data to send your operators and how to most effectively display it. Our System Integration Engineering (SIE) group has the experience to help.

With the 3500/92 and SIE, we've made it easier and more economical than ever to properly interface your machinery protection system to the rest of your plant control and automation systems – improved products and a wider array of value-added services. Call your Bently Nevada sales professional to learn more.

- Performance maps
- Vibration detail
- Turbine bearing temperatures
- Compressor bearing temperatures
- Compressor cold permissive
- Turbine cold start sequence
- Turbine cold start permissive
- Turbine hot start sequence
- Turbine hot start permissive
- Information screens
- Maintenance screens

From each detail screen, you can also see subscreens. For instance, from the turbine detail screen, you can view temperature or vibration data. From the overview screen, you can view turbine details, compressor details, critical points, suction drum levels, and journal bearings.

Anti-surge details feature inlet pressure and temperatures, discharge pressure and temperatures, and pop-up compressor performance maps. The system monitors the operating point, which is determined by the polytropic head and inlet flow.

Remote Access for Added Support

The Bently Nevada and Woodward systems support modem access. This allows an off-site user (whether MAP, Bently Nevada, Woodward, or a third party) with proper passwords and software to remotely access the system and perform machinery diagnostics or system troubleshooting/testing. In the event that an outside assessment of the Data Manager 2000 data is needed, Bently Nevada offers an optional Remote Services contract using their Machinery Management Services (MMS) Engineers.

Conclusions

Initially, we hoped this upgrade would allow us to operate the hydrogen recycle unit for ten years before a shutdown. **Results were even better than we expected; we have extended the planned shutdown out to fifteen to seventeen years.** The system is easy to use and has resulted in significant cost savings, due to the elimination of unnecessary shutdowns. We have an integrated system that provides excellent value. The success of this project was due largely to the teamwork provided by MAP, Bently Nevada, and Woodward. MAP personnel, such as Unit Operators, Unit Managers, Operation Managers, and the Corporate VP, were also involved in the project and decision making to make sure that safety was kept as a priority while focusing on extending the time between shutdowns.

As a result of the success of this installation, two additional control systems, with integrated Bently Nevada protection/management systems, have been installed on electric motor driven units in cat cracker service: a 25,000 hp blower and a 15,000 hp gas compressor. Bently Nevada has consistently provided the best available technology for this application.